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(54) **ELECTRODE ASSEMBLY**

(57) An electrode assembly, in which a positive electrode, a separator, and a negative electrode are repeatedly stacked, according to the present invention comprises: at least two or more positive electrodes which are stacked in the electrode assembly and each of which has a structure in which a positive electrode active material is applied to a surface of a positive electrode collector, wherein the positive electrode active material contains nickel, cobalt, and manganese, and a composition ratio of nickel, cobalt, and manganese in the positive electrode active material applied to one positive electrode is different from that of nickel, cobalt, and manganese in the positive electrode active material applied to the other positive electrode.

According to the present invention having the technical characteristics as described above, the positive electrodes, in which the positive electrode active material has the different composition ratios of nickel, cobalt, and manganese, may be stacked to adequately improve thermal stability and capacity.

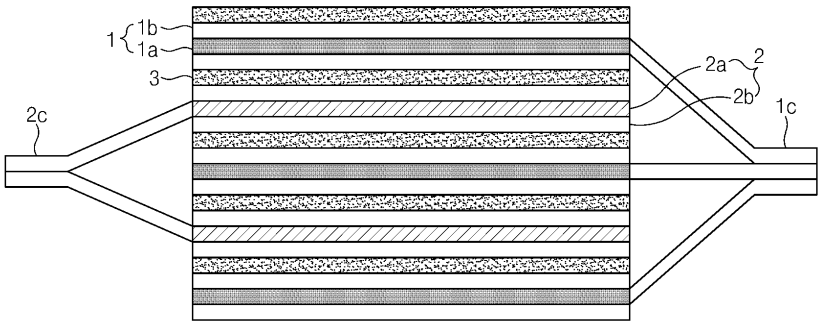

FIG.1A

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Description

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application claims the benefit of the priority of Korean Patent Application No. 10-2018-0151259, filed on November 29, 2018, which is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

[0002] The present invention relates to an electrode assembly, and more particularly, to an electrode assembly in which two or more positive electrodes are stacked, and each positive electrode has a structure in which a positive electrode active material having a different composition ratio is applied to a positive electrode collector to simultaneously increase in charging/discharging capacity and thermal stability.

BACKGROUND ART

[0003] Batteries storing electrical energy may be generally classified into primary batteries and a secondary batteries. Such a primary battery is a disposable consumable battery. On the other hand, such a secondary battery is a chargeable battery that is manufactured by using a material in which oxidation and reduction processes between current and the material are capable of being repeated. That is, when the reduction reaction to the material is performed by the current, power is charged, and when the oxidation reaction to the material is performed by the current, power is discharged. Here, such the charging-discharging are repeatedly performed.

[0004] Among various types of secondary batteries, lithium secondary batteries are generally manufactured by mounting an electrode assembly, in which a positive electrode, a separator, and a negative electrode are stacked, in a case. Here, as a process, in which lithium ions are intercalated and deintercalated from lithium metal oxide to the negative electrode, is repeated to charge and discharge the lithium secondary batteries.

[0005] The electrode assembly may be manufactured so that a positive electrode 1/a separator 3/a negative electrode 2 are stacked repeatedly. The electrode assembly is accommodated in a can such as a cylindrical can or a prismatic case. As illustrated in FIG. 1A in which a side view of the electrode assembly is illustrated, the positive electrode 1 of the electrode assembly is coated with a positive electrode active material 1b on both surfaces of a positive electrode collector 1a, and the negative electrode 2 is coated with a negative electrode active material 2b on both surfaces of the negative electrode collector 2a. Here, a negative electrode tab 2c and a positive electrode tab 1c (which are expanded in a state in which the active materials are not applied) protrude from the negative electrode collector 2a and the positive electrode collector 1a in the negative electrode 2 and the positive electrode 1 so that current flows through the negative electrode tab 2c and the positive electrode tab 1c, respectively.

[0006] As demands for secondary batteries increase in fields such as energy storage system (ESS) and electric vehicles, research and development are being conducted to increase in capacity of secondary batteries.

[0007] As a result, a secondary battery using an NCM (nickel (Ni), cobalt (Co), and manganese (Mn))-based positive electrode material has been developed. However, the NCM-based secondary battery has a problem that, when a nickel content relatively increases, the capacity increases, but the thermal stability decreases, and thus, the possibility of ignition also increases. FIG. 1b is a graph illustrating a state in which the thermal stability varies depending on the nickel content. FIG. 1b(A) illustrates results of a thermal stability test of the electrode assembly coated with the positive electrode active material in which a composition ratio of nickel (Ni), cobalt (Co), and manganese (Mn) is 6:2:2, and FIG. 1b(B) illustrates results of a thermal stability test of the electrode assembly coated with the positive electrode active material in which a composition ratio of nickel (Ni), cobalt (Co), and manganese (Mn) is 8:1:1. The thermal stability test was performed by measuring a temperature change (a vertical axis) versus time (a horizontal axis) while heating is performed at a temperature of 80°C to 200°C at a rate of 2K/min. It is seen that both the electrode assemblies are ignited and damaged (at a point at which a cell voltage [Cell V] is zero; 460 minutes at which the cell voltage is zero in FIG. 1b(A), and 280 minutes at which the cell voltage is zero in FIG. 1b(B)), but the ignition more quickly occurs in the electrode assembly coated with the positive electrode active material having a composition ratio of 8:1:1 than the electrode assembly coated with the positive electrode active material having a composition ratio of 6:2:2. That is, it is seen that the thermal stability is deteriorated as the nickel content increases.

DISCLOSURE OF THE INVENTION

TECHNICAL PROBLEM

[0008] Accordingly, the present invention is to provide a secondary battery that is capable of using a positive electrode active material having a high nickel content so as to improve capacity as well as thermal stability.

TECHNICAL SOLUTION

[0009] According to the present invention for achieving the above object, an electrode assembly in which a positive electrode, a separator, and a negative electrode are repeatedly stacked comprises: at least two or more positive electrodes which are stacked in the electrode assembly and each of which has a structure in which a positive electrode active material is applied to a surface of a positive electrode collector, wherein the positive

electrode active material contains nickel, cobalt, and manganese, and a composition ratio of nickel, cobalt, and manganese in the positive electrode active material applied to one positive electrode is different from that of nickel, cobalt, and manganese in the positive electrode active material applied to the other positive electrode.

[0010] According to the present invention, the positive electrode disposed at the relative outside in a stacking direction of the electrode assembly may be coated with a positive electrode active material containing a relatively small amount of manganese and a relative large amount of nickel, and the positive electrode disposed at the relative inside in the stacking direction of the electrode assembly may be coated with a positive electrode active material containing a relatively large amount of manganese and a relative small amount of nickel.

[0011] According to Embodiment 1 of the present invention, the positive electrode disposed at the relative outside in the stacking direction of the electrode assembly may be coated with a positive electrode active material in which nickel, cobalt, and manganese are contained at a ratio of 8:1:1, and the positive electrode disposed at the relative inside in the stacking direction of the electrode assembly may be coated with a positive electrode active material in which nickel, cobalt, and manganese are contained at a ratio of 1:1:1.

[0012] According to Embodiment 2 of the present invention, the positive electrode disposed at the relative outside in the stacking direction of the electrode assembly may be coated with a positive electrode active material in which nickel, cobalt, and manganese are contained at a ratio of 6:2:2, and the positive electrode disposed at the relative inside in the stacking direction of the electrode assembly may be coated with a positive electrode active material in which nickel, cobalt, and manganese are contained at a ratio of 1:1:1.

[0013] According to Embodiment 3 of the present invention, the positive electrode disposed at the relative outside in the stacking direction of the electrode assembly may be coated with a positive electrode active material in which nickel, cobalt, and manganese are contained at a ratio of 8:1:1, and the positive electrode disposed at the relative inside in the stacking direction of the electrode assembly may be coated with a positive electrode active material in which nickel, cobalt, and manganese are contained at a ratio of 6:2:2.

[0014] Also, the electrode assembly may have a structure in which three or more positive electrodes are stacked and comprise: one or more positive electrodes coated with a positive electrode active material in which nickel, cobalt, and manganese are contained at a ratio of 1:1:1; one or more positive electrodes coated with a positive electrode active material in which nickel, cobalt, and manganese are contained at a ratio of 6:2:2; and one or more positive electrodes coated with a positive electrode active material in which nickel, cobalt, and manganese are contained at a ratio of 8:1:1.

[0015] A positive electrode tab of the positive electrode coated with the positive electrode active material containing a relatively small amount of manganese and a relatively large amount of nickel and a positive electrode tab of the positive electrode coated with the positive electrode active material containing a relatively large amount of manganese and a relatively small amount of nickel may be disposed to be separated from each other.

[0016] A negative electrode tab disposed on the negative electrode in the electrode assembly may be disposed on one side, and the positive electrode tab is disposed on an opposite side, and the positive electrode tab of the positive electrode coated with the positive electrode active material containing the relatively small amount of manganese and the relatively large amount of nickel and the positive electrode tab of the positive electrode coated with the positive electrode active material containing the relatively large amount of manganese and the relatively small amount of nickel may be disposed to be spaced a predetermined distance from each other.

[0017] The electrode assembly having the above-described technical feature may be embedded in a case to provide a secondary battery, and the secondary battery may be provided in plurality, which are electrically connected to each other to provide a secondary battery module.

ADVANTAGEOUS EFFECTS

[0018] According to the present invention having the technical characteristics as described above, the positive electrodes, in which the positive electrode active material has the different composition ratios of nickel, cobalt, and manganese, may be stacked to adequately improve the thermal stability and the capacity.

[0019] In more detail, the positive electrode active material containing a large amount of nickel to realize the high capacity may be disposed on the positive electrode disposed on the outside (the degradation may occur due to the relatively difficult heat dissipation), and the positive electrode active material containing a small amount of nickel to increase in thermal stability may be disposed on the positive electrode disposed on the inside to relatively improve the thermal stability and the capacity when compared to the case of using any kind of positive electrode.

[0020] Furthermore, the positive electrode tab of the positive electrode coated with the positive electrode active material containing the relatively large amount of nickel and the positive electrode tab of the positive electrode coated with the positive electrode active material containing the relatively small amount of nickel may be disposed to be separated from each other to additionally reduce the electrical resistance (because the current flows to be divided).

BRIEF DESCRIPTION OF THE DRAWINGS

[0021]

FIG. 1a is a side view of an electrode assembly according to a related art.

FIG. 1b is a graph illustrating a state in which thermal stability varies depending on a nickel content.

FIG. 2a is a side view illustrating an electrode assembly according to a first embodiment of the present invention.

FIG. 2b is a side view illustrating an electrode assembly according to a second embodiment of the present invention.

FIG. 2c is a side view illustrating an electrode assembly according to a third embodiment of the present invention.

FIG. 3 is a plan view of an electrode assembly according to the present invention.

MODE FOR CARRYING OUT THE INVENTION

[0022] Hereinafter, preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings in such a manner that the technical idea of the present invention may easily be carried out by a person with ordinary skill in the art to which the invention pertains. The present invention may, however, be embodied in different forms and should not be construed as limited to the embodiments set forth herein.

[0023] In order to clearly illustrate the present invention, parts that are not related to the description are omitted, and the same or similar components are denoted by the same reference numerals throughout the specification.

[0024] Also, terms or words used in this specification and claims should not be restrictively interpreted as ordinary meanings or dictionary-based meanings, but should be interpreted as meanings and concepts conforming to the scope of the present invention on the basis of the principle that an inventor can properly define the concept of a term to describe and explain his or her invention in the best ways.

[0025] The present invention relates to an electrode assembly in which a positive electrode 10 (10', 10", and 10'"), a separator 30, and a negative electrode 20 are repeatedly stacked. Here, at least two or more positive electrodes 10 are stacked so that positive electrode active materials 10b applied to the positive electrodes 10 have different composition ratios.

[0026] In more detail, in the present invention, the positive electrode 10 is coated with the positive electrode active material 10b containing nickel, cobalt, and manganese. Here, a composition ratio of nickel, cobalt, and manganese in the positive electrode active material 10b applied to one positive electrode may be different from that of nickel, cobalt, and manganese in the positive electrode active material 10b applied to the other positive electrode.

[0027] Furthermore, according to the present invention, in order to improve thermal stability at an intermediate portion at which heat dissipation is difficult, the positive electrodes 10' and 10'" disposed at the relative outside in a stacking direction of the electrode assembly are coated with the positive electrode active material (a high Ni-based active material) containing a relatively small amount of manganese and a relative large amount of nickel, and the positive electrode 10" disposed at the relative inside in the stacking direction of the electrode assembly is coated with the positive electrode active material (a low Ni-based active material) containing a relatively large amount of manganese and a relative small amount of nickel. Here, the amount of nickel is relatively determined.

[0028] Hereinafter, embodiments of the present invention will be described in detail with reference to the accompanying drawings.

First Embodiment

[0029] Referring to FIG. 2a which illustrates a side view of an electrode assembly according to a first embodiment (for reference, although three positive electrodes are stacked in FIGS. 2a to 2c, three or more positive electrodes may be stacked), the electrode assembly according to this embodiment has a structure that is stacked downward in order of separator 30/positive electrode 10'/separator 30/negative electrode 20/separator 30/positive electrode 10"/separator 30/negative electrode 20/separator 30/positive electrode 10'".

[0030] The negative electrode has a structure in which a negative electrode active material 20b is applied to both surfaces of a negative electrode collector 20a, and the positive electrode 10 (10', 10", and 10'") has a structure in which a positive electrode active material 10b is applied to both surfaces of a positive electrode collector 10a. The positive electrode active material 10b is manufactured by containing lithium, cobalt, and manganese. Here, the positive electrodes disposed at the relative outside in a stacking direction of the electrode assembly, i.e., the first positive electrode 10' and the third positive electrode 10'", which are disposed downward from an upper side may have a structure in which nickel, cobalt, and manganese are contained at a ratio of 8:1:1. On the other hand, the positive electrode active material 10b of the positive electrode 10" disposed at the relative inside in the stacking direction of the electrode assembly has a structure in which nickel, cobalt, and manganese are contained at a ratio of 1:1:1.

Second Embodiment

[0031] Referring to FIG. 2b which illustrates a side view of an electrode assembly according to a second embodiment, the electrode assembly according to this embod-

iment has a structure that is stacked downward in order of separator 30/positive electrode 10'/separator 30/negative electrode 20/separator 30/positive electrode 10"/separator 30/negative electrode 20/separator 30/positive electrode 10'".

[0032] Similarly, the positive electrode active material 10b is manufactured by containing lithium, cobalt, and manganese. Here, the positive electrodes disposed at the relative outside in a stacking direction of the electrode assembly, i.e., the first positive electrode 10' and the third positive electrode 10'", which are disposed downward from an upper side may have a structure in which nickel, cobalt, and manganese are contained at a ratio of 8:1:1. On the other hand, the positive electrode active material 10b of the positive electrode 10" disposed at the relative inside in the stacking direction of the electrode assembly has a structure in which nickel, cobalt, and manganese are contained at a ratio of 6:2:2.

[0033] The electrode assembly according to this embodiment has a configuration that focuses on increasing capacity rather than thermal stability because a nickel content of the electrode assembly according to this embodiment is slightly less than that of the electrode assembly according to the first embodiment.

Third Embodiment

[0034] Referring to FIG. 2c which illustrates a side view of an electrode assembly according to a third embodiment, the electrode assembly according to this embodiment has a structure that is stacked downward in order of separator 30/positive electrode 10'/separator 30/negative electrode 20/separator 30/positive electrode 10"/separator 30/negative electrode 20/separator 30/positive electrode 10'".

[0035] Similarly, the positive electrode active material 10b is manufactured by containing lithium, cobalt, and manganese. Here, the positive electrodes disposed at the relatively outside in a stacking direction of the electrode assembly, i.e., the first positive electrode 10' and the third positive electrode 10'", which are disposed downward from an upper side may have a structure in which nickel, cobalt, and manganese are contained at a ratio of 6:2:2. On the other hand, the positive electrode active material 10b of the positive electrode 10" disposed at the relatively inside in the stacking direction of the electrode assembly has a structure in which nickel, cobalt, and manganese are contained at a ratio of 1:1:1.

[0036] The electrode assembly according to this embodiment has a configuration that focuses on increasing thermal stability rather than capacity because a nickel content of the electrode assembly according to this embodiment is less than that of the electrode assembly according to each of the first and second embodiments.

[0037] For reference, in the electrode assembly according to the present invention, three or more positive electrodes may be stacked. Thus, three kinds of positive electrodes having different compositions of nickel, cobalt, and manganese may be stacked.

[0038] In this case, it is preferable that the positive electrode coated with the positive electrode active material having a low nickel content is disposed at the inside in which heat dissipation is relatively difficult, and the positive electrode coated with the positive electrode active material having a high nickel content is disposed at the outside in which the heat dissipation is relatively easy. For example, it is assumed that five positive electrodes are stacked downward from the upper side, positive electrodes coated with the positive electrode active material in which nickel, cobalt, and manganese are contained at a ratio of 8:1:1 may be respectively provided as first and fifth positive electrodes that are the outermost positive electrodes, positive electrodes coated with the positive electrode active material in which nickel, cobalt, and manganese are contained at a ratio of 6:2:2 may be provided as second and fourth positive electrodes, and a positive electrode coated with the positive electrode active material in which nickel, cobalt, and manganese are contained at a ratio of 1:1:1 may be provided as a third positive electrode (having relatively the lowest nickel content).

[0039] In the electrode assembly configured as described above, it is preferable that the positive electrodes 10 having the same composition ratio are electrically connected to each other. That is, since electrical conductivity of the positive electrode active material 10b are changed also as the composition ratio varies, it is preferable that the positive electrodes having different composition ratios are disposed to be separated from each other. When the positive electrode tabs are divided according to the composition ratios, current may flow to be divided. Thus, cell damage may be minimized to increase in lifespan of the battery. Also, the positive electrode having relatively high thermal stability may be charged by applying high current, and the positive electrode having relatively low thermal stability may be charged by applying low current.

[0040] Referring to FIG. 3, which illustrates a plan view of the electrode assembly according to the present invention, a positive electrode tab 10c' of a first positive electrode 10' and a positive electrode tab of a third positive electrode 10a'", which have the same composition ratio, may be bonded and connected to each other. On the other hand, a positive electrode tab 10c" of the second positive electrode 10" and a positive electrode tab 10c' of the first positive electrode 10', which have different composition ratios, may be disposed to be spaced apart from each other. Here, since the negative electrode tab 20c disposed on the negative electrode 20 in the electrode assembly is disposed on one side, the positive electrode tabs are disposed at intervals on the same side of an opposite side.

[0041] According to the present invention having the technical characteristics as described above, the positive electrodes, in which the positive electrode active material 10b has the different composition ratios of nickel, cobalt, and manganese, may be stacked to adequately improve

the thermal stability and the capacity.

[0042] In more detail, the positive electrode active material containing a large amount of nickel to realize the high capacity may be disposed on the positive electrode disposed on the outside (the degradation may occur due to the relatively difficult heat dissipation), and the positive electrode active material containing a small amount of nickel to increase in thermal stability may be disposed on the positive electrode disposed on the inside to relatively improve the thermal stability and the capacity when compared to the case of using any kind of positive electrode.

[0043] Furthermore, the positive electrode tab of the positive electrode coated with the positive electrode active material containing the relatively large amount of nickel and the positive electrode tab of the positive electrode coated with the positive electrode active material containing the relatively small amount of nickel may be disposed to be separated from each other to additionally reduce the electrical resistance (because the current flows to be divided).

[0044] The electrode assembly having the above-described technical feature may be embedded in a case to provide a secondary battery, and a plurality of secondary batteries may be electrically connected to provide a secondary battery module.

[0045] While the embodiments of the present invention have been described with reference to the specific embodiments, it will be apparent to those skilled in the art that various changes and modifications may be made without departing from the spirit and scope of the invention as defined in the following claims.

Claims

1. An electrode assembly in which a positive electrode, a separator, and a negative electrode are repeatedly stacked, the electrode assembly comprises:

   at least two or more positive electrodes which are stacked in the electrode assembly and each of which has a structure in which a positive electrode active material is applied to a surface of a positive electrode collector,
   wherein the positive electrode active material contains nickel, cobalt, and manganese, and
   a composition ratio of nickel, cobalt, and manganese in the positive electrode active material applied to one positive electrode is different from that of nickel, cobalt, and manganese in the positive electrode active material applied to the other positive electrode.

2. The electrode assembly of claim 1, wherein the positive electrode disposed at the relative outside in a stacking direction of the electrode assembly is coated with a positive electrode active material containing a relatively small amount of manganese and a relative large amount of nickel, and
   the positive electrode disposed at the relative inside in the stacking direction of the electrode assembly is coated with a positive electrode active material containing a relatively large amount of manganese and a relative small amount of nickel.

3. The electrode assembly of claim 2, wherein the positive electrode disposed at the relative outside in the stacking direction of the electrode assembly is coated with a positive electrode active material in which nickel, cobalt, and manganese are contained at a ratio of 8:1:1, and
   the positive electrode disposed at the relative inside in the stacking direction of the electrode assembly is coated with a positive electrode active material in which nickel, cobalt, and manganese are contained at a ratio of 1:1:1.

4. The electrode assembly of claim 2, wherein the positive electrode disposed at the relative outside in the stacking direction of the electrode assembly is coated with a positive electrode active material in which nickel, cobalt, and manganese are contained at a ratio of 8:1:1, and
   the positive electrode disposed at the relative inside in the stacking direction of the electrode assembly is coated with a positive electrode active material in which nickel, cobalt, and manganese are contained at a ratio of 6:2:2.

5. The electrode assembly of claim 2, wherein the positive electrode disposed at the relative outside in the stacking direction of the electrode assembly is coated with a positive electrode active material in which nickel, cobalt, and manganese are contained at a ratio of 6:2:2, and
   the positive electrode disposed at the relative inside in the stacking direction of the electrode assembly is coated with a positive electrode active material in which nickel, cobalt, and manganese are contained at a ratio of 1:1:1.

6. The electrode assembly of claim 2, wherein the electrode assembly has a structure in which three or more positive electrodes are stacked and comprises: one or more positive electrodes coated with a positive electrode active material in which nickel, cobalt, and manganese are contained at a ratio of 1:1:1; one or more positive electrodes coated with a positive electrode active material in which nickel, cobalt, and manganese are contained at a ratio of 6:2:2; and one or more positive electrodes coated with a positive electrode active material in which nickel, cobalt, and manganese are contained at a ratio of 8:1:1.

7. The electrode assembly of claim 2, wherein a posi-

tive electrode tab of the positive electrode coated with the positive electrode active material containing a relatively small amount of manganese and a relatively large amount of nickel and a positive electrode tab of the positive electrode coated with the positive electrode active material containing a relatively large amount of manganese and a relatively small amount of nickel are disposed to be separated from each other.

8. The electrode assembly of claim 7, wherein a negative electrode tab disposed on the negative electrode in the electrode assembly is disposed on one side, and the positive electrode tab is disposed on an opposite side, and
the positive electrode tab of the positive electrode coated with the positive electrode active material containing the relatively small amount of manganese and the relatively large amount of nickel and the positive electrode tab of the positive electrode coated with the positive electrode active material containing the relatively large amount of manganese and the relatively small amount of nickel are disposed to be spaced a predetermined distance from each other.

9. A secondary battery in which the electrode assembly of any one of claims 1 to 8 is embedded in a case.

10. A secondary battery module in which the secondary battery of claim 9 is provided in plurality, which are electrically connected to each other.

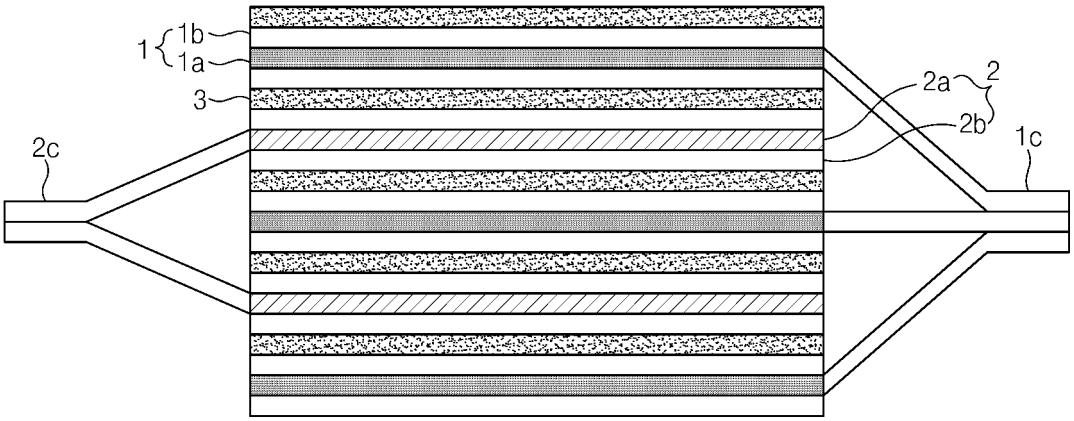
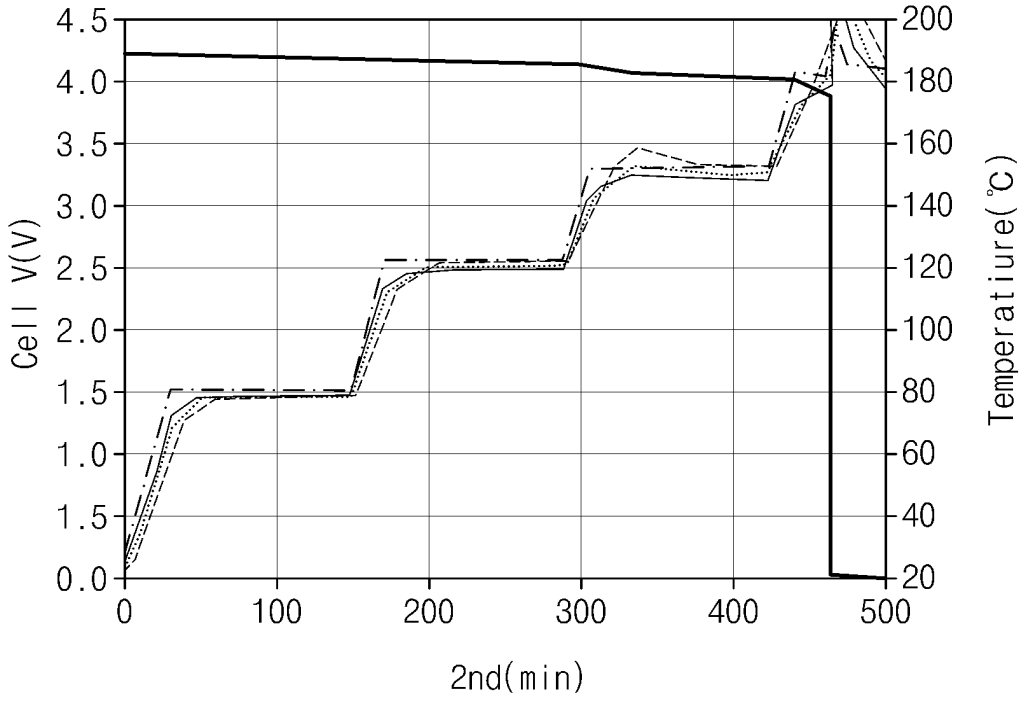


FIG.1A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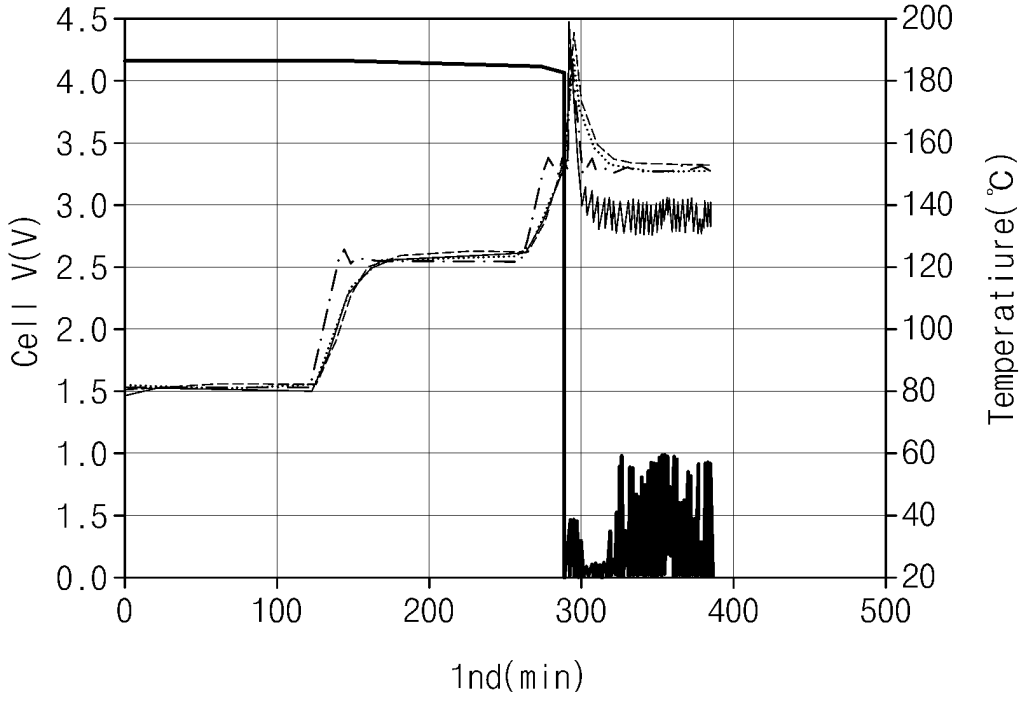
(A)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(B)

FIG.1B

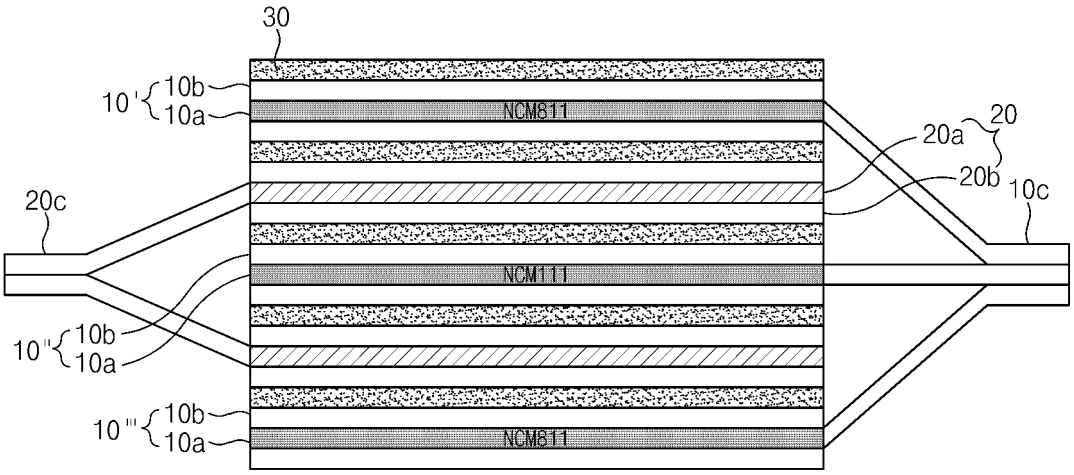
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FIG.2A

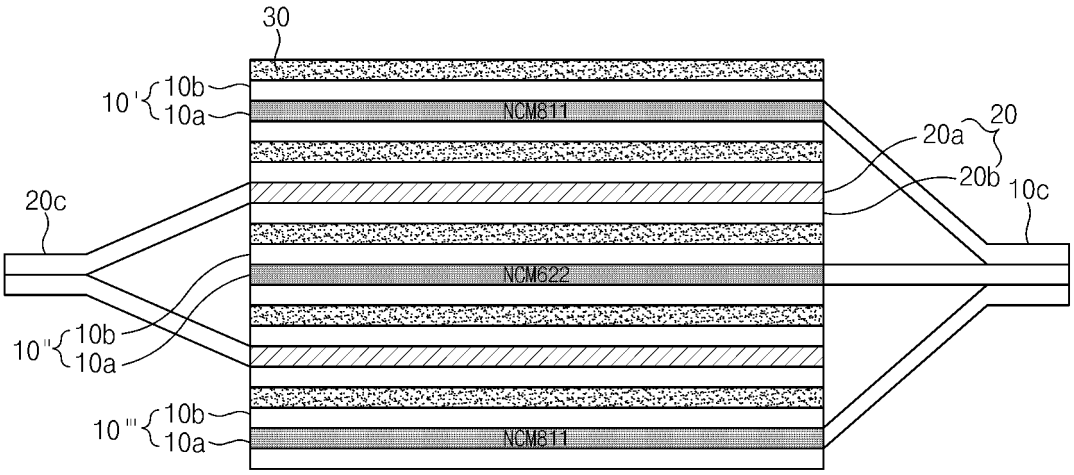
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FIG.2B

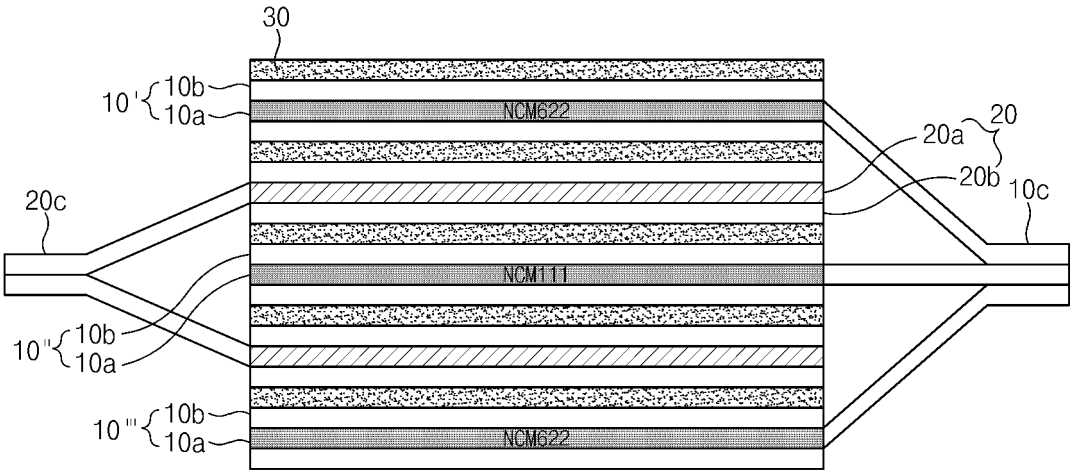
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FIG.2C

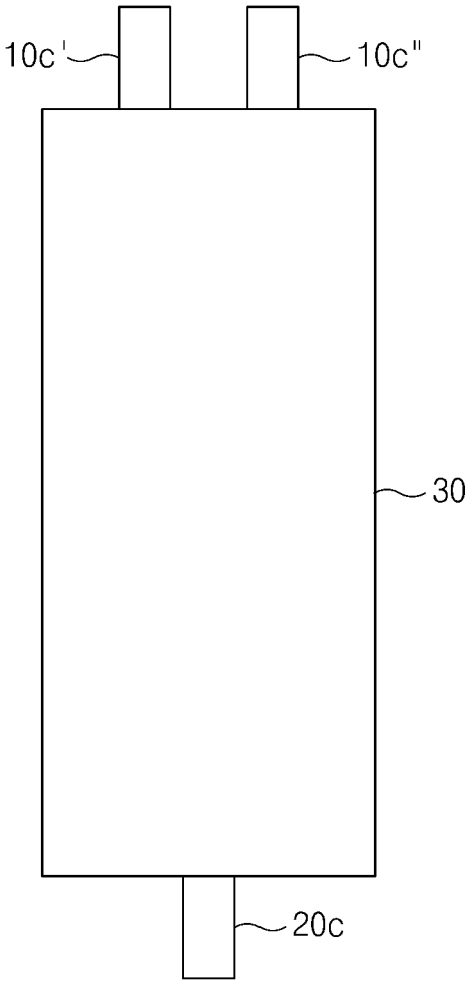

FIG.3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2019/012745

A. CLASSIFICATION OF SUBJECT MATTER
H01M 10/0585(2010.01)i, H01M 4/131(2010.01)i, H01M 4/525(2010.01)i, H01M 4/505(2010.01)i, H01M 2/26(2006.01)i, H01M 10/052(2010.01)i
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01M 10/0585; H01M 10/04; H01M 10/0525; H01M 14/00; H01M 2/16; H01M 4/04; H01M 4/13; H01M 4/133; H01M 4/38; H01M 4/58; H01M 4/131; H01M 4/525; H01M 4/505; H01M 2/26

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models: IPC as above
Japanese utility models and applications for utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS (KIPO internal) & Keywords: cathode, stack, nickel, cobalt, manganese

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 10-2016-0012454 A (SK INNOVATION CO., LTD.) 03 February 2016 See abstract; claims 9-14; and paragraphs [0030], [0088]-[0099].	1-10
A	EP 3107138 B1 (SAMSUNG SDI, CO., LTD.) 18 April 2018 See abstract; and claims 1-14.	1-10
A	WO 2006-113807 A2 (A123 SYSTEMS, INC.) 26 October 2006 See the entire document.	1-10
A	KR 10-2013-0026522 A (MOLECULAR NANOSYSTEMS, INC.) 13 March 2013 See the entire document.	1-10
A	JP 2017-063041 A (SONY CORP.) 30 March 2017 See the entire document.	1-10

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
03 JANUARY 2020 (03.01.2020)	**03 JANUARY 2020 (03.01.2020)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex Daejeon Building 4, 189, Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea Facsimile No. +82-42-481-8578	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2019/012745

Patent document cited in search report	Publication date	Patent family member	Publication date
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		KR 10-2016-0113571 A	30/09/2016
		US 2016-0028062 A1	28/01/2016
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		US 10305136 B2	28/05/2019
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		EP 2474037 A2	11/07/2012
		JP 2013-504168 A	04/02/2013
		US 2011-0123866 A1	26/05/2011
		WO 2011-029058 A2	10/03/2011
		WO 2011-029058 A3	12/04/2012
JP 2017-063041 A	30/03/2017	JP 6264429 B2	24/01/2018

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- KR 1020180151259 **[0001]**